CoCoRaHS Observers Contribute to "Condition Monitoring" in the Carolinas

A New Initiative Addresses Needs for Drought Impacts Information

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MOTIVATION. Drought experts and policy makers have long cited a need for more systematic efforts to collect, assess, and apply drought impacts data. Drought impacts information can provide insights regarding drought severity as well as social, economic, and ecological vulnerabilities. Such information is an important component of drought monitoring, response, mitigation, and preparedness activities (Hayes et al. 2011; NIDIS 2012; Western Governors Association 2004; Wilhite et al. 2007).

Two examples of existing drought impacts reporting mechanisms include the National Drought Mitigation Center's Drought Impact Reporter (NDMC DIR) and citizen science impact reports submitted by Community Collaborative Rain, Hail, and Snow (CoCoRaHS) volunteers (www.cocorahs.org). The DIR (http://droughtreporter.unl.edu/map/) was launched in 2005 and offers a "snapshot" view of drought through various sources of impacts information, including media reports and reports submitted directly through the website. The national network of approximately 20,000 CoCoRaHS observers submits daily precipitation measurements, but they also have the option to record supplemental information regarding hail, heavy rain, snow, and drought conditions. Drought impacts reports are incorporated into the DIR.

Unfortunately, reports submitted through these and other systems can be fragmented, only capturing impacts information when drought becomes severe. They often center on the agricultural and water resources sectors; information from a broader range of sectors (recreation, tourism, public health) is limited. Furthermore, it is unclear the extent to which decision makers connect to, or use, impacts information (Lackstrom et al. 2013; Meadow et al. 2013).

The initiative described here was designed to address these needs and gaps. The impetus came from a 2012 meeting to identify priorities for the National Integrated Drought Information System (NIDIS) Coastal Carolinas Drought Early Warning System (DEWS) (www.drought.gov/drought/dews/coastal-carolinas). Participants recommended a project to help build public awareness of drought impacts, advance understanding of the linkages between drought and on-the-ground conditions, and capture more information about drought onset, intensification, and recovery. They also suggested that existing tools and resources (such as the DIR and CoCoRaHS) be considered in the development and implementation of the project (Brennan et al. 2012; Reges et al. 2016).

Based on these stakeholder recommendations, the Carolinas Integrated Sciences and Assessments (CISA) program (http://cisa.sc.edu/) initiated the "Citizen Science Condition Monitoring" project in 2013. The

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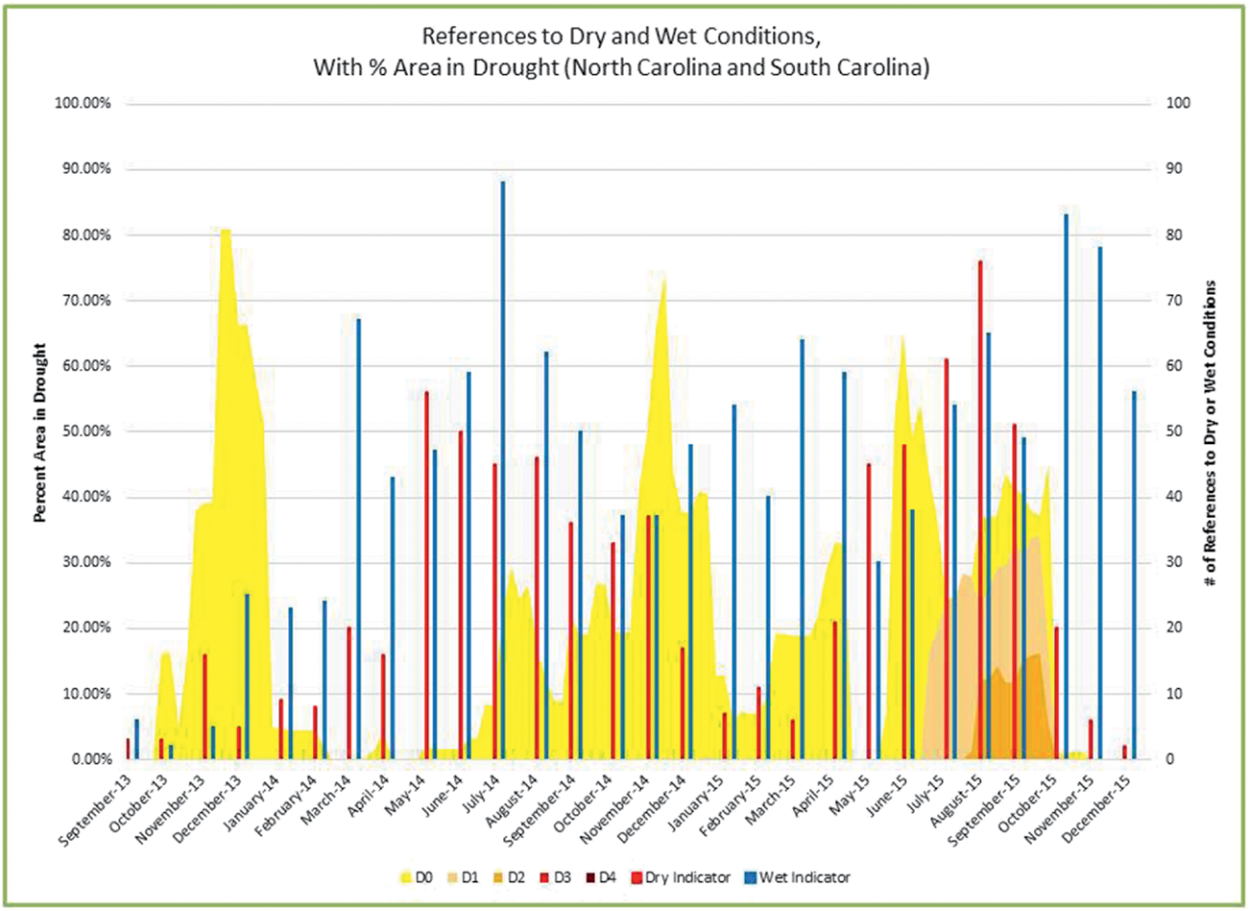

Fig. 1. ***Volunteer Reports Correspond to Changing Conditions.*** **CISA used the QSR NVivo software program (version 10) to code and analyze condition monitoring report content. This graph shows the number of coded references to dry and wet conditions, per month, from September 2013 to December 2015. After the initial recruitment period (September–December 2013), volunteers submitted an average of 62 reports per month. Drought severity is shown in the background, based on U.S. Drought Monitor designations for North Carolina and South Carolina for that time period (http://droughtmonitor.unl.edu/Data.aspx).**

project has involved close collaboration with NDMC and CoCoRaHS personnel to develop and promote an experimental method of drought monitoring and reporting by citizen scientists. This article shares information about the "condition monitoring" approach and a new web map designed to enhance communication of drought conditions and impacts (http://cisa.sc.edu/cocorahs.html).

PHASE 1 (2013–15): DESIGNING AND TESTING THE CONDITION MONITORING APPROACH. The primary objective of phase 1 was to assess 1) the feasibility of condition monitoring, and 2) the ability of citizen scientists to provide useful information for drought-related decisions. The condition monitoring approach involves submitting regular status reports about the condition of an observer's local environment and community. Consistent reporting is intended to create a baseline for comparison of change over time and a mechanism to monitor deteriorating, or improving, conditions. This contrasts with more typical drought impacts data collection, which is done either intermittently or through "one off" (often postdrought) reports (Lackstrom et al. 2013).

In preparation for the project, CISA worked with CoCoRaHS and NDMC to adapt existing reporting mechanisms. CoCoRaHS added a condition monitoring check box to its online "Drought Impact Report Form." This allowed report users to easily distinguish "one off" drought impact reports from condition monitoring reports. CISA developed a suite of

training and information materials, available through the CoCoRaHS and CISA websites, to provide guidance about writing and submitting weekly reports.

Phase 1 consisted of three core activities: volunteer recruitment and engagement, assessment of condition monitoring report content, and interviews with report users and decision makers. Because the Coastal Carolinas DEWS program was designed to improve understanding of coastal drought, CISA initially targeted groups located in coastal areas. CISA conducted three in-person events and four webinars between August 2013 and June 2014. The 112 attendees included CoCoRaHS volunteers, master naturalists, master gardeners, and other environmentally focused citizen scientists. Due to the strong interest of CoCoRaHS observers, CISA expanded the recruitment effort with that group. State and regional CoCoRaHS coordinators helped to distribute project information, thereby building a larger network of volunteers.

From September 2013 to December 2015, 68 CoCoRaHS observers in the Carolinas submitted 1,572 condition monitoring reports. Approximately 42 of the 68 observers attended one of the training events; the remaining 26 observers were existing CoCoRaHS volunteers who learned about the project through outreach to this network. The reports included weather observations (precipitation amounts, temperature, extreme events) and information about weather effects (both dry and wet conditions) on their households and communities (Fig. 1). Reports focused primarily on agriculture, horticulture, landscaping, water resources, and unmanaged plants and wildlife. Consistent reporters

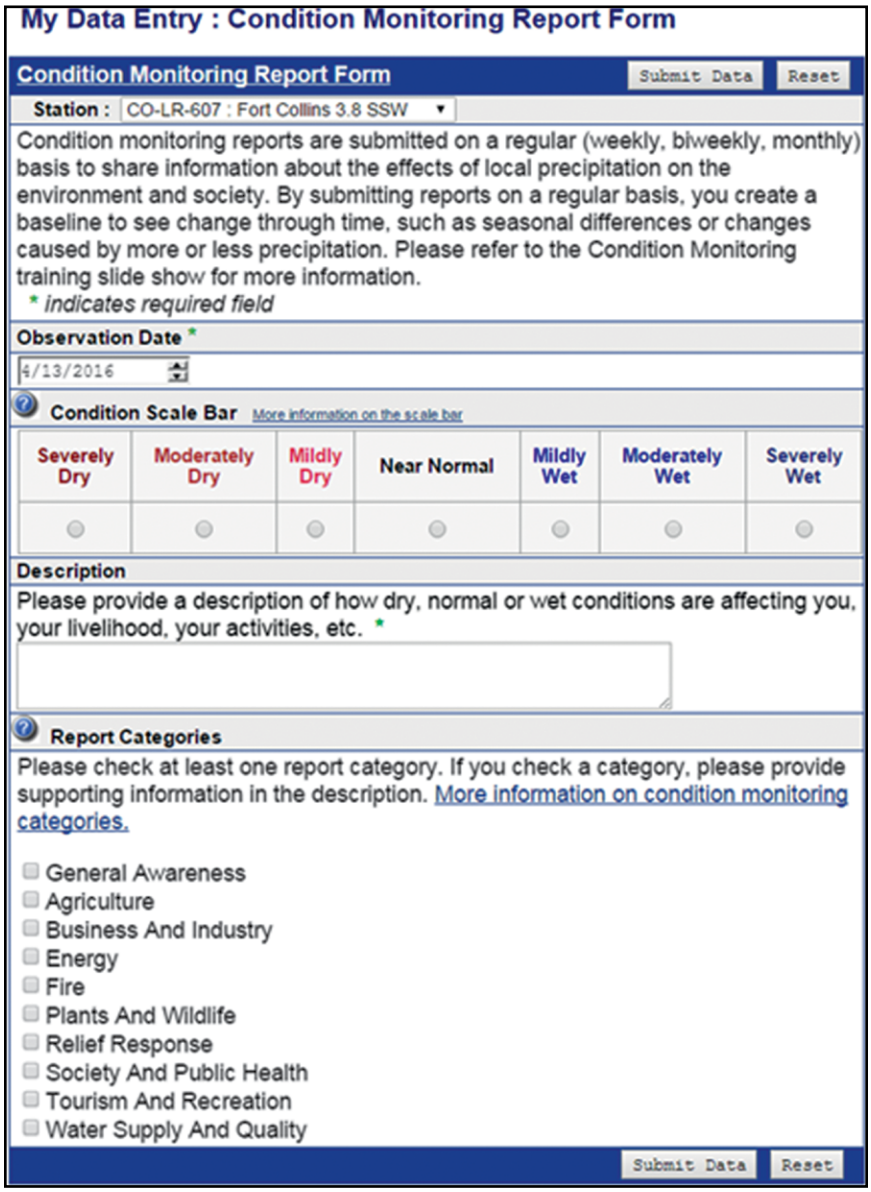

Fig. 2. ***The Condition Monitoring Report Form.*** **CoCoRaHS observers use the "Condition Monitoring Scale Bar" to record their assessment of local conditions, ranging from severely dry to severely wet, and enter qualitative reports in the "Description" box. The "Report Categories" correspond to the categories used by NDMC's Drought Impact Reporter. The form also includes links to the "Condition Monitoring Resource Page" on the CoCoRaHS website. This page provides guidance for completing the form and additional information about condition monitoring. (www.cocorahs.org/Content.aspx?page=condition)**

indicated change over time by referencing specific sites or objects (e.g., garden soil moisture conditions, lake or stream levels) and specific events (e.g., the October 2015 rainfall event in South Carolina).

Throughout phase 1, CISA used focus group calls, online surveys, and interviews to obtain feedback from CoCoRaHS volunteers and potential users of the reports (e.g., State Climate Offices, National Weather Service offices, U.S. Drought Monitor authors, and state drought response committees). Volunteers indicated that CISA's regular outreach to observers helped to sustain their interest in the project. A primary motivation for volunteer participation was learning more about how their reports are used. Users indicated that they perceived the reports to be a potential positive contribution to drought monitoring; in particular, they considered volunteers who consistently submitted daily precipitation measurements as reliable and credible sources of condition monitoring information. To improve the usefulness and usability of the reports, this group also noted a need for improved accessibility to the reports as well as summary information that would facilitate a quick assessment of changing conditions.

PHASE 2 (2015–17): ENHANCING THE CONDITION MONITORING PROCESS. Informed by the needs and suggestions identified in phase 1, new activities focus on streamlining the reporting process and improving the communication and visualization of the reports. For phase 2, CoCoRaHS transitioned the original "Drought Impact Report Form" to a "Condition Monitoring Report Form" by removing unused parts of the form and adding a condition monitoring scale bar. Also, CISA developed a web map to spatially display the condition monitoring reports (www.cocorahs.org/maps/conditionmonitoring/). CISA, CoCoRaHS, NDMC, and drought decision makers contributed to the development of these new resources.

CoCoRaHS observers use the scale bar to record their assessment of local conditions, ranging from

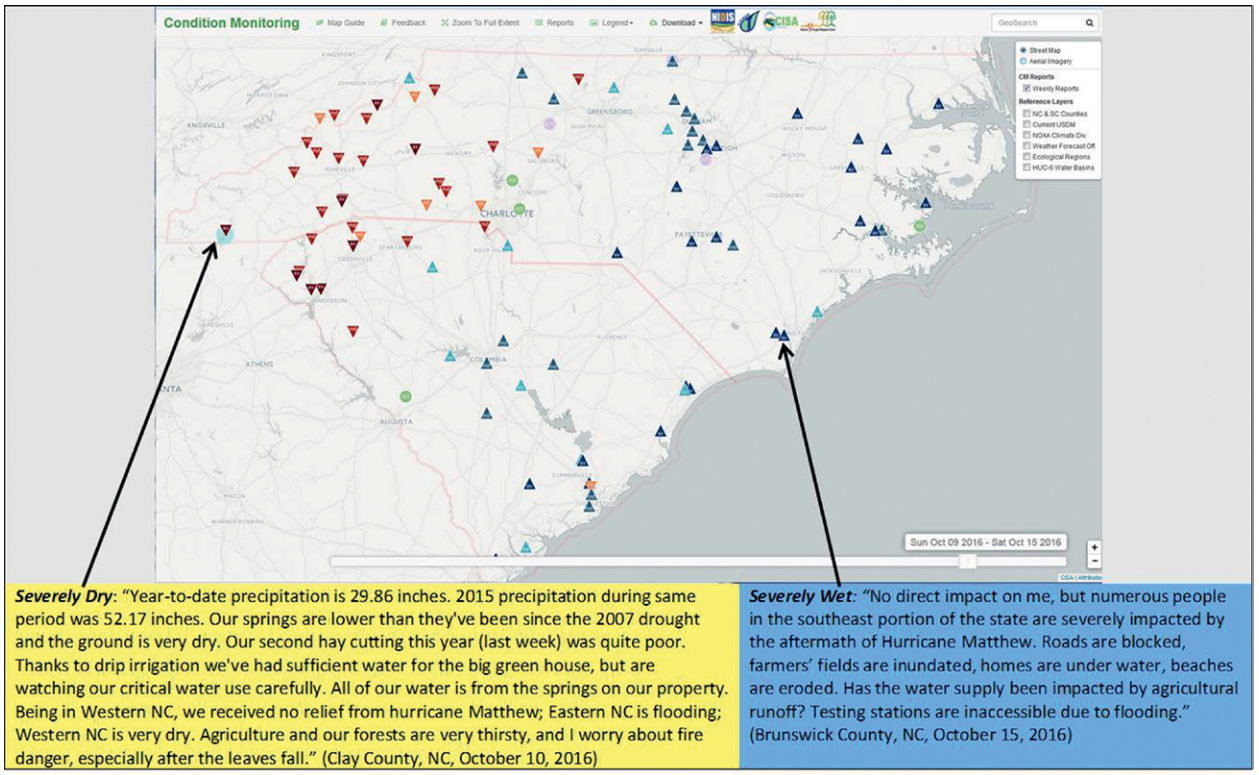

Fig. 3. *The Condition Monitoring Web Map, Carolinas Prototype*. The condition monitoring web map spatially displays citizen scientists' reports (blue triangles represent wet conditions, inverted red triangles represent dry conditions, and green circles represent near-normal conditions). The map includes a search function and various reference layers (e.g., U.S. Drought Monitor, counties, climate divisions, and National Weather Service Forecast Office boundaries). Users can download the reports in comma-separated value, shapefile, or GeoJSON formats.

severely wet to severely dry (Fig. 2). Their qualitative reports provide in-depth information about their selection. CoCoRaHS added the scale bar to the condition monitoring report form and launched it nationally in October 2016. Between 10 October 2016 and 30 June 2017, observers throughout the United States submitted 11,075 reports. North and South Carolina observers submitted 1,675 of these reports.

The web map provides an accessible format for users to view the reports (Fig. 3). State Climate Office of North Carolina personnel currently use the web map to help identify changing conditions for the weekly drought assessments conducted by the North Carolina Drought Management Advisory Council. The condition monitoring reports can supplement the information provided by objective drought indicators and offer a fuller picture of what is happening across the state. The reports can also be used for other types of weather and climate monitoring, reporting, and research. For example, observers have provided detailed impacts information from events such as the October 2015 rainfall and flooding event in North and South Carolina, Hurricane Matthew's landfall in October 2016, and the fall 2016 wildfires in the western Carolinas.

FUTURE PLANS. Building off the Carolinas beta version of the web map, CISA and CoCoRaHS worked together to launch a national web map. and are developing additional tools to further enhance access to and use of the report data. CISA continues to assess the condition monitoring process for its effectiveness in informing drought monitoring and decision making through surveys and interviews with users at the State Climate Offices, National Weather Service offices, and other relevant agencies and sectors (e.g., drought committees, agriculture, water resources). Ongoing communications and outreach is critical to retain volunteers and encourage continuous reporting. As condition monitoring expands to the national level, sharing information about how the reports are used will help to support the observer network and contribute to the success of the program.

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FOR FURTHER READING

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